



The relationship between agriculture and the environment is the subject of increasingly heated debate. The aim of this paper is not to explain all of the controversy's technical aspects, but rather to formulate a general framework which will allow for a convergence of the “two Green Revolutions.”

Jacques Delors, Founding President of *Notre Europe*

Achieving a Doubly Green Revolution

*Agriculture and the Environment: Ambivalence and Fragility
Are these Core Issues Affecting Human Balances*

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“Over the past 50 years, humans have changed these ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fibre, and fuel.”¹ This mode of development is having a brutal effect on other living species: in 2008, 22% of the 26,604 mammals were threatened with extinction and the IUCN² added that “it is increasingly evident that climate change is going to become one of the main causes of species extinction in the 21st century.”³ Even though international climate negotiations scheduled for December in Copenhagen may well reach a stalemate over financing issues, warnings about environmental imbalances are of greater concern than ever. From the scientific community’s vantage point, climate, natural resources and biodiversity must be preserved, inasmuch as the loss of one species or one resource affects the entire ecosystem on which the survival and progress of human society depends.

As pointed out by M. Mazoyer and L. Roudart, since Neolithic times, human development has relied on “the transformation of original ecosystems into cultivated, exploited and artificialized ecosystems (...). Since then, agriculture has conquered the world; it has become the primary factor in the ecosphere’s transformation, and its production and productivity gains have respectively had an impact on human population growth and the development of social categories that do not produce their own food.”⁴ At a time when our mode of development threatens the sustainability of our natural resources, agriculture – the major link in the chain binding man and nature – is being scrutinized in terms of the impact of its practices. It is doubly concerned by the future of ecosystems: first,

1. “Millennium Ecosystem Assessment Report” (2005), <http://www.millenniumassessment.org/en/index.aspx>.
2. International Union for the Conservation of Nature.
3. Species Susceptibility to Climate Change Impacts, http://cmsdata.iucn.org/downloads/climate_change_and_species.pdf.
4. Marcel Mazoyer, *Histoire des agricultures du monde* (Laurence Roudart: 1997).

as a direct agent of environmental transformations, and second, as a user dependent on natural resources and a potential victim of damages inflicted on the latter. This interdependency between agricultural practices and the environment reflects the dilemma posed by our mode of development: progress derives its momentum from natural resources but it is approaching a stage in which the pressure it is placing on them could irreparably destroy them.

Modern ecology⁵ evolved from an awareness of the effects of human activity on the environment. It induces us to engage in some critical thinking about the impact of our development on our ecosystems. The application of ecology to agriculture first appeared in 1924, when Rudolf Steiner drew public attention to so-called “biological” practices in his pioneer writings. Despite sustained market growth, organic farming still concerns a minority of farms today,⁶ since its costs remain higher than those of conventional farming.

Given this context in which decision-makers, farmers and citizens are being pressured to make choices, neither conventional farming nor organic farming seems to be able to meet the food, ecological and human challenges inherent in a world population growth likely to peak at 9 billion people by 2050. The options now being explored by “Doubly Green Revolution”⁷ researchers seem to offer the potential of preventing the apocalyptic scenario of global famine and the destruction of natural resources which we are already facing. They are calling for an agricul-

5. Term coined by German biologist Ernst Haeckel (1866). Ecology is the science which studies the relationship of organisms with their environment.
6. For a perspective on organic farming and its prospects, see Sylvie Bonny, *Organic Farming in Europe: Situation and Prospects, Notre Europe* (2006), http://www.notre-europe.eu/fileadmin/IMG/pdf/Bonny_Agribio-EN.pdf.
7. The term “Doubly Green Revolution” was coined by Gordon Conway in 1994. Its aim is to “propose a future agriculture for developing countries – a highly productive agriculture (...) to meet increasing global needs which will also be respectful of the environment (...) and which will be equity-based in order to reduce poverty, hunger and malnutrition.” Translation of an excerpt from Michel Griffon’s work, *Nourrir la planète*, p. 12 (2006).

ture that is both more productive and more ecological (hence the term “Doubly Green Revolution”). The revolution which they are proposing, remarkably well explained in France by Michel Griffon, strives to ensure the required leap in quantitative production by relying on the intrinsic qualities of the environments concerned and then by including artificial inputs in them “only when absolutely necessary.” This type of agriculture refuses to give “*priority to solutions based on the intensive use of fertilizers and phytosanitary products, as well as biofuels.*”⁸ Ecology and biology are thus becoming the key disciplines for “*identifying valid new arguments for improving productivity.*”⁹

Although researchers have identified promising prospects for meeting food and environmental challenges, the Doubly Green Revolution demands a radically new approach by decision-makers, farmers and citizens. The goal of this paper, prompted by the European experience, is to take stock of the complex interaction between agriculture and the environment (I) and of the threats which it will need to tackle in the medium term. After pointing out the behavioural inertia involved and the inability of the market to carry out the required ecological changes (II), it proposes several courses of action for initiating a new common agricultural policy which would contribute to the implementation of a Doubly Green Revolution (III).

I – Agriculture’s Ambivalent Relationship to Nature

Humans are, for the most part, responsible for transforming the earth’s environment. Agriculture is one of the leading factors behind the anthropomorphization of nature, in which it plays a dual role: positive when it acts as a necessary regulator of natural balances, biodiversity and landscapes (A), and negative when it leads to a destructive overexploitation of

8. Michel Griffon, *Nourrir la planète* (Odile Jacob: 2006).

9. Op.cit. p.287.

nature (B). The reality of agronomic practices lies somewhere between these two poles of the agriculture-environment relationship.

A. Essential agriculture-environment interaction

After reading the countless articles on agricultural pollutants, people tend to forget that agriculture does not in itself bear the seeds of ecosystem destruction. To the contrary, it has been favourably fostering man-nature balances for thousands of years by selecting the most productive species and/or those best adapted to their geographical environments. It has been preserving animal and plant biodiversity pockets by supplying habitats, preventing ground from turning into vast expanses of scrubland, improving soil quality and, in adapting to their diversity, nourishing that of our own landscapes. It is on this cultivated natural ground so extensively shaped by farmers’ hands, that humanity has been building its demographic, economic and social development upheaval.

The “High Nature Value” (HNV)¹⁰ farming concept, which more and more experts and researchers subscribe to, highlights agriculture’s beneficial contribution to natural balances. In the 1990s, European researchers who formulated it while they were involved in saving the endangered Red-Billed Cough from extinction, observed “*that this bird’s biology depended on preserving agricultural and pastoral practices which maintained the spaces and species which it needed, and thus, in a broader sense, the corresponding production systems.*”¹¹ This situation of an animal species’ dependency on a type of farming applies to many situations throughout Europe. The HNV farming concept thus reinforces reco-

10. Concept formulated in the 1990s by the Institute of European Environmental Policy of London, the WWF United Kingdom and the European Forum on Nature Conservation and Pastoralism (EFNCP). For a French version overview of this concept, see the in-depth report by Xavier Poux and Blandine Romain, “L’agriculture à Haute Valeur Naturelle : mieux la (re)connaître pour mieux l’accompagner,” *European Forum on Nature Conservation and Pastoralism (March 2009)*, http://www.efncp.org/download/HVN_Fascicule060309.pdf.

11. Op.cit

gnition of the contribution made by agricultural activity to the preservation of fragile natural environments, formulated as early as 1975 by the European Commission.¹² HNV farming is not synonymous with organic farming; it is a form of agricultural development which makes it possible to maintain, in exploited ecosystems, natural habitats sheltering a large number of wild species in coexistence with domestic species. It is based on three principles: a production requiring low input (synthetic or organic fertilizers and phytosanitary products), spread out over a large portion of the farmed agricultural area and which ensures a balanced agro-ecosystem. Such agricultural approaches enhance the spaces whose floristic diversity (notably the presence of leguminous plants) and root capacity to draw nutrients from the parent rock help to maintain the soils' natural fertility: prairies, lawns, shrubs and bushes, fruit trees, etc.

The positive role of agriculture is also emerging in recent scientific research conducted on climate change. While agriculture, according to the IPCC,¹³ is responsible for 13.5% of global greenhouse gas emissions, it may also help to reduce these emissions from soils, which are the second largest storage wells after oceans (permanent grassland, for example). However, there is considerable uncertainty about the capacity of soils to perform this function because their storage capacity is hindered by global warming. Moreover, farmers may be the first victims of climate change, as the latter has the potential to increase the likelihood of agricultural disasters (storms, hail, frost, parasites, diseases, etc.). Until additional scientific and technical data emerges to clarify agriculture's contribution to the fight against climate change, public debate on this subject

12. Nadège Chambon and Chiara Tomalino, *Rural Development in EU Policy: A Retrospective, Notre Europe* (June 2009), <http://www.notre-europe.eu/en/axes/competition-cooperation-solidarity/works/publication/rural-development-in-eu-policy-a-retrospective/>.

13. According to the IPCC, "Terrestrial ecological systems, in which carbon is retained in live biomass, decomposing organic matter, and soil, play an important role in the global carbon cycle. Carbon is exchanged naturally between these systems and the atmosphere through photosynthesis, respiration, decomposition, and combustion. Human activities change carbon stocks in these pools and exchanges between them and the atmosphere through land use, land-use change, and forestry, among other activities." IPCC, "Summary for Policymakers," Geneva, Switzerland (2000).

has been stalled in an environment of economic crisis in which no policy leader¹⁴ dares to add any new constraints to already hard requirements.

Farming – particularly when extensive – is helping to balance the ecosystem by making an essential contribution to biodiversity, resource management and our landscapes. Certain types of farming, however, can have devastating effects on natural balances.

B. Agriculture's negative external effects on the environment

This question is not new,¹⁵ but modernization (mechanization, intensification, specialization) initiated after World War II accelerated and amplified these effects. Formerly more localized, pollutions became more widespread (for example, dissemination of pesticide residues) and mechanization and regrouping of land had an impact on landscapes (such as loss of hedges), on wildlife and on water levels (*i.e.* floods). Since the 1970s, water erosion phenomena have been noted in certain regions of Western France. During the 1980s, water contamination by the nitrates used in intensive agriculture became a serious problem. This was the period in which "*the beginning of an increasingly global implication of agriculture with regard to its impact on the environment*" was observed.¹⁶ In the 1990s, the transformation of wetlands – environments particularly rich in animal species – was called into question with increasing vigour, generating conflicts between users such as farmers, environmentalists, hunters, etc.

The European example alone cannot account for all of the changes experienced at the same time by the rest of the world's developed agricul-

14. This phenomenon was observed in France when the issue of agriculture was side-tracked during the carbon tax debates.

15. " [*In the 19th and early 20th centuries, the concern to protect mountains from the effect of erosion caused by overgrazing by livestock was one of the major factors which resulted in an increasing scarcity of goat breeding activity in the Mediterranean region* " *Le Monde paysan au XXI^{ème} siècle*, from an "Ecology" entry (Larousse agricole: 2003).

16. *Ibid.*

tures; however, it exemplifies the impact of intensification. According to the European Environment Agency, the Common Agricultural Policy (CAP), which was inspired by productivist objectives, is actually a decisive reason for the accelerated worsening of the situation: “Historically, the CAP has advocated the rapid intensification and modernization of European agriculture to the detriment of traditional agriculture. The consequences of intensification have been felt in terms of soil erosion, water pollution and the overexploitation of water resources, the loss of biodiversity (semi-natural habitats, wildlife species), damage linked to pesticides and risks to human health.”¹⁷ The adoption of numerous Directives (nitrates, water, biodiversity, Natura 2000, etc.) and CAP reforms have made it possible to curb the spread of intensive agriculture and reduce the adverse effects of its development on the environment,¹⁸ yet without stopping them. Much more work remains to be done.

Intensification’s heavy toll on the environment has given rise to criticisms which have tarnished – and are still tarnishing – European agriculture’s image. Some of the most publicized “scandals” worth mentioning are the destruction of biodiversity (notably ornithological), by arable crops; water and soil pollution by applications of liquid manure and dung from industrial livestock (porcine and poultry) or by chemicals (fertilizers and phytosanitary products); and the depletion of water resources.¹⁹ Closer to France, the nitrates issue resurfaced this summer with the suspicious death in Brittany of a horse and a man thought to have breathed in hydrogen sulphide vapours emitted by decomposing green algae.

However, it would be ill-advised to adopt a simplistic approach (extensive vs. intensive) by condemning all intensive agriculture, insofar as it

enables production requirements to be met and its practices are not always harmful. In fact, when comparing the same practices, the impact varies because every ecosystem is different and sustains farming and breeding techniques to a different degree. This is particularly true of water resources: 24% of all water abstracted in Europe is used for agriculture, “however, these figures mask significant differences in sectoral water use across the continent. In Southern Europe, for example, agriculture accounts for 60% of the total water abstracted and reaches as much as 80% in certain areas.”

It is just as likely that ecosystems may need agriculture to function as it is that they may be destroyed by the latter’s action. To understand this ambivalent interaction, assessments need to be made of agricultural practices and the areas in which they are being implemented. The positive balance between agriculture and the environment which Europeans are striving for by reforming their existing agricultural policy is still delicate because it is threatened by exogenous factors. This will be evident when we examine the prospects for world population growth by 2050 and the slow progress in improving practices when it comes to dealing with the urgent changes necessary to achieve a sustainable agriculture.

II – A Fragile Interaction Facing a Medium-Term Threat

Will the planet be capable of feeding every human being before it has been destroyed? That is the question posed by world population growth, which began two centuries ago and which is expected to reach its peak by the year 2050 (A). The damage already done to natural resources calls for resolute and urgent action, as three conflicting factors are perpetuating behavioural inertia (B).

17. <http://www.eea.europa.eu/themes/agriculture/about-agriculture>.

18. See Thierry de l’Escaille’s study based on an analysis of Birdlife International data (2009).

19. *Subventions directes agricoles et gestion quantitative des ressources en eau*, by Pierre Boulanger, Groupe d’économie mondiale, SciencesPo, http://www.gem.sciences-po.fr/content/publications/pdf/agriculture/Boulanger_IrrigationPAC_GEMPB_FR070907.pdf.

A. Is an ecological and food crisis ahead?

For two centuries, the causes of environmental degradation and the overexploitation of natural resources have been linked to the constant increase in demographic pressure. Yet for the last fifty years, human activity has been upsetting – with unprecedented speed and intensity – the precarious balances between agricultures and their ecosystems. As already seen, this trend stems from an intensification process initiated nearly half a century ago in the historic post-war context. Despite the corrective measures taken, increasing competition between agricultures during the 1990s fuelled such degradation by exerting strong economic pressure on farms. Indeed, profitability constraints can exacerbate the loss of natural biodiversity by promoting the use of additional input likely to pollute soil and water; by clearing out forests in order to expand cultivated land, or by selecting the most productive plant and livestock species. As shown by European Environment Agency figures, “close to half of all livestock breeds in the EU-15 are already extinct, endangered or in critical status (...). The highest proportion of breeds in these categories is in Austria (...). Due to their productivity limitations many of these breeds cannot compete successfully with more modern breeds of farm animals that are better adapted to modern high productivity farming systems.”²⁰ The recent effect of agricultural competition on the environment is all the more alarming in that global food and non-food demand is expected to increase in substantial proportions. It would seem inappropriate for this paper to present quantified data in this study on global agricultural demand by the year 2050, inasmuch as all related benchmark projections²¹ remain prudent in their findings.²² It is nonetheless true that global demographic statistics anticipate that the world population will peak by around 2050 at 9 billion. In addition to this increase in the

20. *Integration of environment into EU agriculture policy: The IRENA indicator-based assessment report*, European Environment Agency, p. 15 (2005), http://www.eea.europa.eu/publications/eea_report_2006_2.

21. See Michel Griffon, *Millennium Ecosystem Assessment (MEA)*, Agrimonde.

22. Working hypotheses are, indeed, both numerous and complex.

number of primarily urban dwellers, developing countries’ consumption patterns should be trending towards diets richer in animal proteins. Since producing one animal protein requires an average seven plant proteins, it will expand agricultural demand in the same proportion. As for non-food demand, world population growth will also have an impact on demand for land, urbanization, clothing, etc. To this already long list of additional pressures facing agriculture should be added the likely demand for energy-related production (bio-diesel fuels and ethanols).

It is in just such a context that fears of a Malthusian crisis²³ are now emerging again, characterized by the inadequacy of food resources to meet demand. Michel Griffon, who has published a remarkable study of this present-day challenge, offers the most likely and promising solution: technology for the ecological intensification of the Doubly Green Revolution. This concept, which designates the transition from current agricultural practices to a series of ecology-based techniques,²⁴ also emphasizes the economic (viability) and social (fairness) dimensions which must be taken into account so that the developing world and the persistent problems of famine and poverty among farmers are not forgotten. It calls for a change in agriculture’s paradigm for a new approach to agriculture as a whole. “*More than a mere technological change, what is needed is a total change of logic, the implementation of which requires a change in farmers’ operative thinking.*”²⁵

23. British economist Thomas Robert Malthus (1766–1834) became widely known for his analysis of the gap between exponential population growth and agricultural production’s mere arithmetic growth and the ensuing risks of famine. His evolution projections were thwarted by agriculture’s technological advances and productivity gains; however, the problem that he raised has historically continued to re-emerge at each new stage of population growth.

24. See “agroécologie,” “Evergreen Revolution,” “Agriculture de conservation” and “Ecoagriculture,” in Griffon’s work (2006).

25. To cite an example: ““The response to insect outbreaks is no longer chemical sprays, but a regulatory solution” Ibid, p. 330.

According to many scientists, the planet could be capable of meeting the food demand of 2050, provided that new ways of thinking, new practices and new regulations were implemented by then. Yet such a revolution is difficult to get off the ground, because three conflicting factors are blocking its progress.

B. The three barriers to change

Considering the urgency of the challenges ahead, the slow pace of change is quite surprising. Three conflicting factors are contributing to the current inertia, which must be overcome. The first has to do with a necessary change of perspective in terms of time: whereas preserving our resources implies confronting long-term challenges, most of the actions and choices being made are based on short-term considerations. If it is in the interest of farms to preserve natural resources in the long run, how can a far-off future be considered when competition and competitiveness constraints demand immediate performance in which the least ecologically committed win the price game? Some farmers manage – with great difficulty – to circumvent the obstacle by turning to niche sectors (such as organic farming, direct sales), while others constantly resort to using creative ways to exploit competitive pockets and match market prices while also meeting tougher environmental requirements. Such is the situation of European producers, who in some cases can no longer compete. An example of this is soy beans destined for use as fodder, which could be produced in Europe, but which is imported in the form of an 80% GMO because cultivating genetically engineered organisms is prohibited in the country. The cost issue is also evident at the level of citizens who demand sustainable crops but who, as consumers, refuse – most of the time – to pay the additional cost that this requirement entails. Similar behaviours are seen at the level of international negotiations, with the developing countries reminding the wealthy countries that economic growth must take precedence over environmental and climate protection objectives.

The urgent need to move towards more productive and sustainable agricultural practices also comes up against the slow pace at which these new principles are democratically implemented. Bernard Perret²⁶ stressed this problem, while mentioning the time the stakeholders need to negotiate, for information to be disseminated and for environmental norms to be enforced and monitored. In France, for example, the Nitrates Directive was the subject of a dialogue between the actors involved which lasted many months before legislation was translated into action. The time needed to meet democratic requirements is just as understandable as the dissatisfaction of local associations who are observing, in real time, the ongoing ecological damage in the field.

Lastly, the revolution that we must undertake in order to put a stop to our environmental misdeeds is confronting, head on, the conservative ways of thinking which have dominated our choices and actions since the 1960s. Hervé Morize[†], President of the Société des Agriculteurs de France until 2009, expressed this and acknowledged the farmers' share of responsibility for the slow pace of change: *“Agriculture, no doubt out of respect for the Green Revolution, is reluctant to do away with its rules; all it has done since 1960 is to gradually change them.”*²⁷ It is only fair to farmers to recognize the share of responsibility borne by professional and research institutions which also are contributing to such reluctance to change. Indeed, the guidelines and policies defined in the second half of the 20th century were all aimed at the same objective: to produce more, thanks to scientific and technological advances. The policy choices made by the Member States have more or less facilitated the change in practices, as exemplified by the increase in investments – which vary considerably from one Member State to the next – devoted to farmer training.

26. Bernard Perret, *Le capitalisme est-il durable ?* (Carnetsnord: 2009).

27. 160 recommendations for a new direction in agriculture, Société des Agriculteurs de France: 2009).

This brief overview of the trends at work is a reminder that, in order to avoid the already-engaged scenario of an ecological and food catastrophe, the transition to a Doubly Green Revolution must be initiated without delay. Yet this radical change in ways of thinking and practices is inconceivable if not encouraged or supported, because it will need to win over short-term profitability projections and conservative attitudes about existing practices. Therefore, to safeguard the public goods constituted by healthy, sustainable ecosystems capable of feeding humanity, what policy can bring about these desirable changes?

III – What kind of policy can bring about a Doubly Green Revolution?

As shown above, the marketplace alone cannot ensure respect for the environment. That is why the role of governments, as guarantors of public interest and public goods, can act as an essential lever in steering agriculture in the direction of ecologically sustainable development (A). Two types of interventions must be carried out to achieve this: first, remuneration of public goods produced by agriculture (B); next, a choice of investments in agricultural research, since meeting the food challenge requires finding the means to achieve a highly productive green agriculture (C).

A. No ecological agriculture is possible without public funds

The “Doubly Green Revolution” concept refers to a multi-dimensional approach to agriculture progress: one that is agricultural, ecological, economic and social. Its advantage is that it allows for these dimensions to be thought of as a whole, rather than compartmentally. It automatically eliminates extreme change solutions which, for example, would impose ecological practices without considering their impact on producers’ income.

As pointed out by Jean-Christophe Bureau and Louis-Pascal Mahé,²⁸ authors of *Notre Europe’s report on CAP beyond 2013*, “Protection of the environment and effective contribution to rural development need a better place in the definition of the means and instruments of the future CAP. However, one central objective of EU farm policy should remain the promotion of competitive agriculture, able to feed the EU population at low cost and to be economically viable. The two objectives are not in contradiction. Resource conservation is a factor in long-term competitiveness (...).”

An ecology-based sustainable production implies the sort of know-how and observation and adaptation capacities which are part and parcel of a complex agriculture. This focuses on the type of farms which play a crucial role for the environment, such as “traditional”-type structures that have had sufficient time to establish agro-ecological balances in harmony with the domestic and wildlife genetic heritage present within a given geographic area.²⁹ Maintaining their practices implies offering them modernization models which will guarantee their viability in areas in which the marketplace is less prone to reward environmentally friendly behaviours. The commercial soundness of such farms can be strengthened, for example, by networking federated local actors around a common territorial and rural project (such as the Maremma Rural District in Tuscany).

Bearing in mind the need to acknowledge each sector’s economic constraints, moving towards a Doubly Green Revolution is predicated upon funding the environmental services provided by the agricultural sector which are not paid for by the market.

28. J. C. Bureau and L. P. Mahé, *CAP reform beyond 2013: An idea for a longer view*, *Notre Europe*, 2008 . Available without charge on the website www.notre-europe.eu.

29. On this topic, see the outstanding research work and photographs of Philippe Deschamps, an expert in land animal photography: <http://www.philippe-deschamps.fr/> and <http://www.animaux-de-terroir.org/>.

B. A new era in agricultural policy: funding environmental services

Modernizing agriculture entails dealing with a central issue: that of private land ownership. According to economic history, the first industrial revolution was set in motion by the Enclosure Act of 1801, which obliged landowners to enclose their properties. This legal obligation established the system which, on one hand, allowed landlords – the future “gentlemen farmers”³⁰ – to use methods that would make their land more profitable and, on the other hand, induced non-landowner farmers to migrate to the cities. Although agriculture is essential to our environment and our landscapes, for the time being such services are not being rewarded and are thus not being promoted. In order for the farmers to be in a position to manage these public goods properly, they need to be backed by agricultural policies that give them the incentive to do so. This is what the authors of Notre Europe’s CAP 2013 study propose by suggesting a total overhaul of the way the CAP provides support: “*Clearly, the size of the individual payments and hence of the EU farm budget that we propose should be calibrated so as to be in line with the economic benefits provided by the farm sector, both regarding positive environmental externalities and the husbandry of the countryside.*”³¹ Three levels of service are contemplated:

1) Services for maintaining space for domestic agriculture in order to preserve rural resources and EU farming landscapes: This would involve a basic payment per hectare of land farmed under certain conditions (for example, EUR 100 or 150/ha, to give an order of magnitude

³⁰ Thus, two centuries after the science of agronomy was founded by Vivarais Olivier de Serres, the British are now becoming actors in the modern agronomy field: Jethro Tull (1674–1741), with the mechanical seeder; Lord Townsend (1674–1738) with systematic crop rotation and the creation of artificial pastures to improve winter cattle feeding and the introduction of beet farming in England; Robert Bakewell (1726–1795) and Thomas W. Coke (1754–1842) with selective livestock breeding; Arthur Young (1741–1820) with the dissemination of knowledge. See Mazerolle, *Cours d'économie*, <http://www.mazerolle.fr/>.

³¹ J. C. Bureau and L. P. Mahé, *Notre Europe*, 2008. They proposed the following terms to describe the payment system, which are all extracted from *CAP reform beyond 2013. An idea for a longer view*.

(...). This payment would be granted to all farms, including commercial and intensive farms, which accept a contract to manage the land and to preserve farming landscapes.

2) The continuation of farming activity in areas and regions with natural handicaps (the territorial services): This is a system of higher payments for regions with one or several natural handicaps (sparsely populated, remote, mountainous, northern and arid regions, etc.). This payment may be coupled with farming activity, inasmuch as production and environmental services are credible complements. In particular, dairy, beef and suckler cows, sheep and goats can be assigned an effective multifunctional role provided that stocking rates are kept low.

3) Positive efforts to preserve and restore natural resources in designated rural areas endowed with high natural value or those considered environmentally sensitive: These are special contracts covering certain environmental services valued more highly than the commitments contracted within the Basic Husbandry Payments (BHPs) framework (1). Farms in environmentally sensitive areas located in less fertile regions (as well as in pockets of territories otherwise dedicated to commercial farming) are eligible under certain conditions related to farm practices, such as lands devoted to extensive grazing.

Payment for environmental and territorial services supplied by the agricultural sector is an absolute prerequisite for inducing farmers to adopt sustainable practices. However, making the transition to a doubly green agriculture will require considerable scientific and technological progress before transition can be made to an ecologically intensive agriculture. This will be possible only if substantial public funds are committed to research.

C – Investing in agricultural research: changing practices

Tomorrow's agricultural sector must change its practices and notably reduce its dependency on inputs: fertilizers, pesticides, seeds, cattle feed, irrigation water and biofuels. In France, input represents, on average, 60% of total farm turnover, and agriculture consumes about 250 litres of biofuel equivalent per hectare.³² The magnitude of the changes that need to be made is obvious. But producing more with less input requires “*large investments in infrastructures and in research – not only to increase yields per se, but to develop and spread agricultural production systems that are compatible with the preservation of ecosystems and can resist climate change.*”³³ Indeed, scientific and technological know-how which might serve as a basis for the Doubly Green Revolution are currently inadequate to deal with the dual ecological and productive constraints. Agricultural research is therefore the key which will open the door to more promising perspectives. Finding this key relies on public funding, but also on combining scientific progress with local or empirical know-how because it “*often consists of acquiring knowledge and data on how living systems and ecosystems function, production processes, etc.*”³⁴ which farmers possess. According to Xavier Poux,³⁵ the profound mutation leading to a high-performance environmental agriculture not only depends on techniques but calls for “*the integration of environmental norms into consumer behaviour,*” which necessarily implies the reformulation of a new and unusually strong *social and political “contract” comparable to the one which prevailed when the CAP was implemented in the 1960s.*”

32. Figures provided by France Nature Environnement, 2009.

33. Agrimonde Foresight Study Working Group, http://www.paris.inra.fr/var/prospective/storage/fckeditor/file/Agrimonde8p_en.pdf.

34. Sylvie Bonny, *Notre Europe*, 2006, http://www.notre-europe.eu/fileadmin/IMG/pdf/Bonny_Agrbio-EN.pdf.

35. *Agriculture, environnement et territoires : quatre scénarios à l'horizon 2025* (Groupe de la Bussière: 2006).

Conclusion

Even though the climate change issue calls for immediate attention, other concerns are resurfacing about resource depletion, pollution, soil erosion and the loss of biodiversity.

Agriculture, which has an ambivalent relationship with the environment, can enrich these natural resources – or destroy them. The effect it will have depends on the type of agriculture concerned and the region in which it is practiced. If humanity destroys the land on which its development depends, it will very quickly endanger its own survival, because no man-engineered solution can replace the natural cycle which renews our food resources. However, that could happen as the result of rising population growth and the pressures which people are placing on agriculture and the environment. While a wide-scale change of practices would be required to avoid an apocalyptic scenario of famine and exhausted resources, these changes are obviously slow in coming.

Therefore, in order to initiate a complete transformation of current mentalities and to start practicing an ecologically intensive agriculture – the only way of meeting medium-term challenges in the future – agricultural policies must seize this new opportunity and make a commitment to pursue three directions. First, protect the economic viability of farms so as to make certain that their essential presence will be maintained; second, ensure that public services not paid for by the market are rewarded in order to provide an incentive for such practices; third, find scientific and technological solutions for this new type of agriculture, which has yet to be developed. All of this has a cost which society must be aware of and willing to accept in an environment of strong budgetary pressure. But will Europeans, who are now primarily urban, be capable of grasping such unfamiliar agricultural constraints?